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(54) **METHOD AND SYSTEM FOR VIRTUAL MACHINE BACKUP**

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CPC ***G06F 3/0641*** (2013.01); ***G06F 3/065*** (2013.01); *G06F 11/1456* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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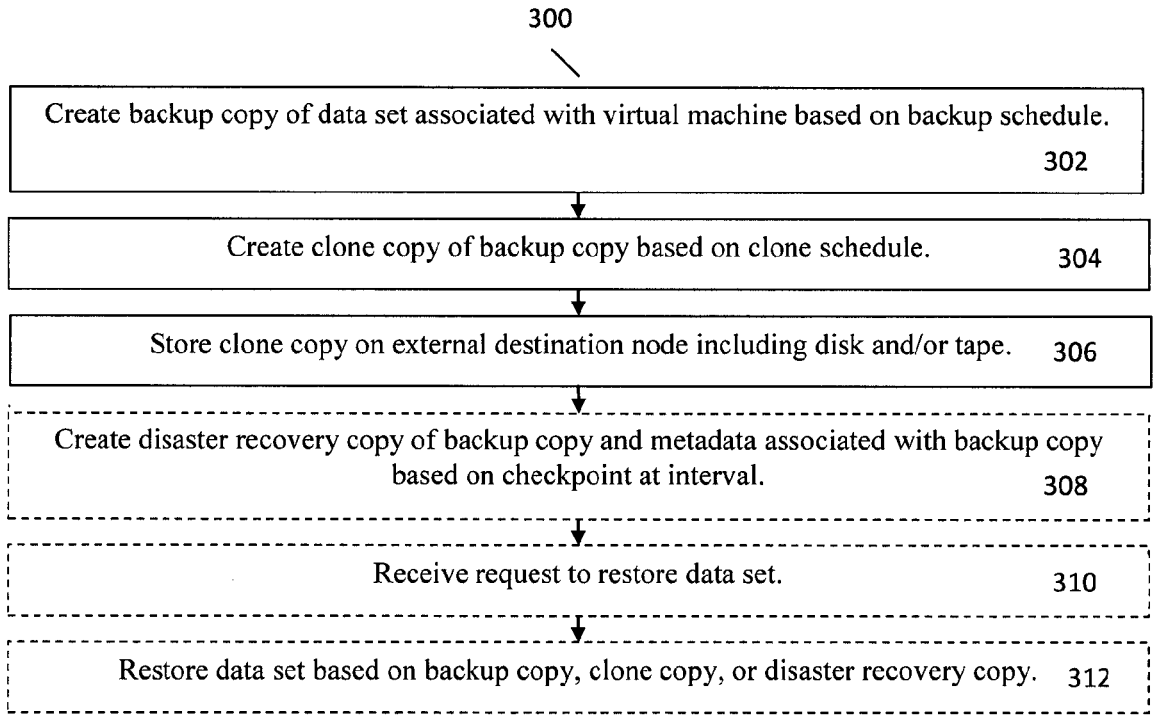
(57) **ABSTRACT**

Virtual machine backup is described. A backup copy is created of a data set associated with a virtual machine based on a backup schedule. A clone copy is created of the backup copy based on a clone schedule. The clone copy is stored on an external destination node including a disk and/or a tape. A disaster recovery copy may be created of the backup copy and metadata associated with the backup copy based on a checkpoint at an interval. A request to restore the data set may be received. The data set may be restored based on the backup copy, the clone copy, or the disaster recovery copy.

20 Claims, 3 Drawing Sheets



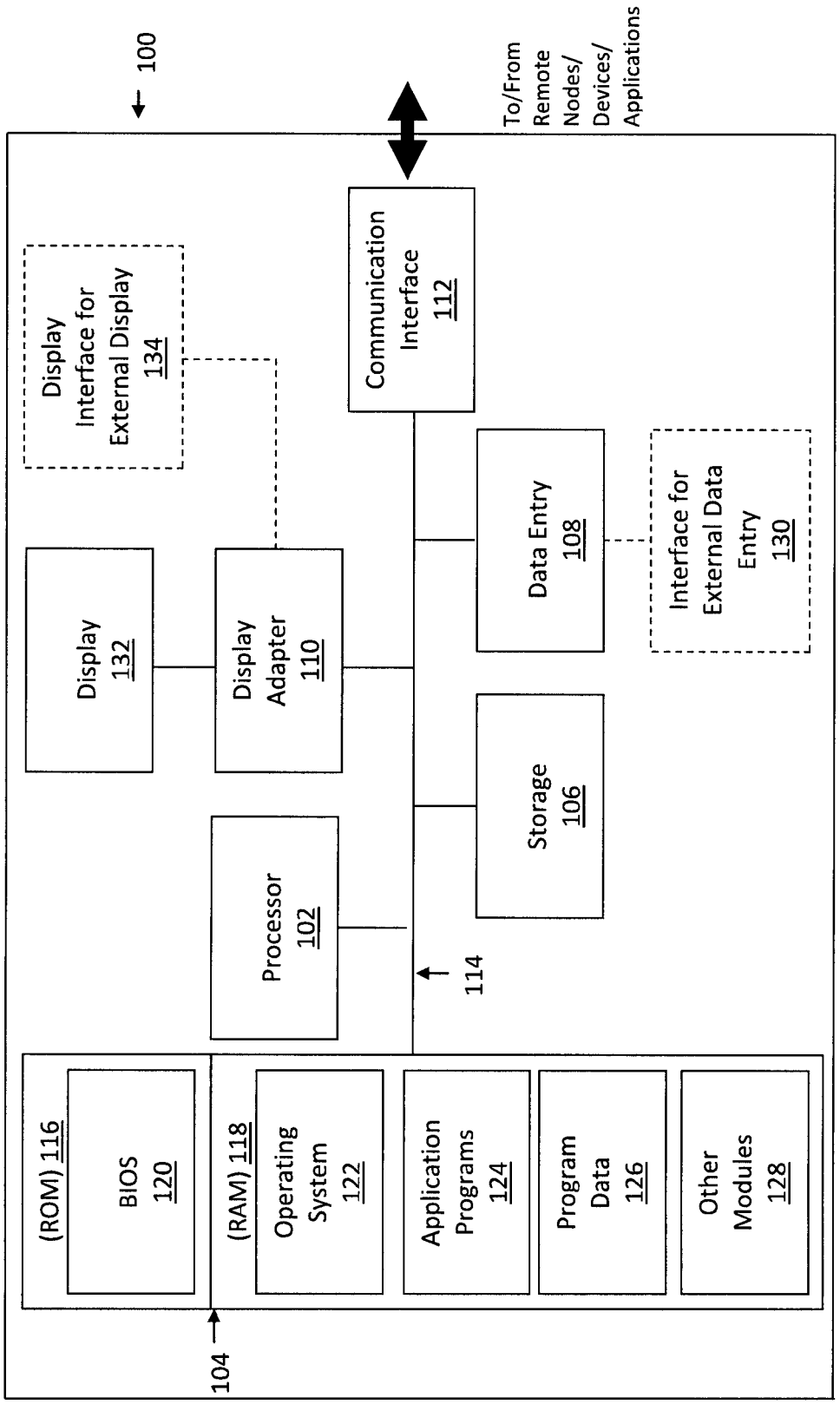

100
To/From Remote Nodes/ Devices/ Applications
Communication Interface 112
Display Interface for External Display 134
Display 132
Display Adapter 110
Data Entry 108
Interface for External Data Entry 130
Storage 106
Processor 102
114
(ROM) 116
BIOS 120
(RAM) 118
Operating System 122
Application Programs 124
Program Data 126
Other Modules 128
104

FIG. 1

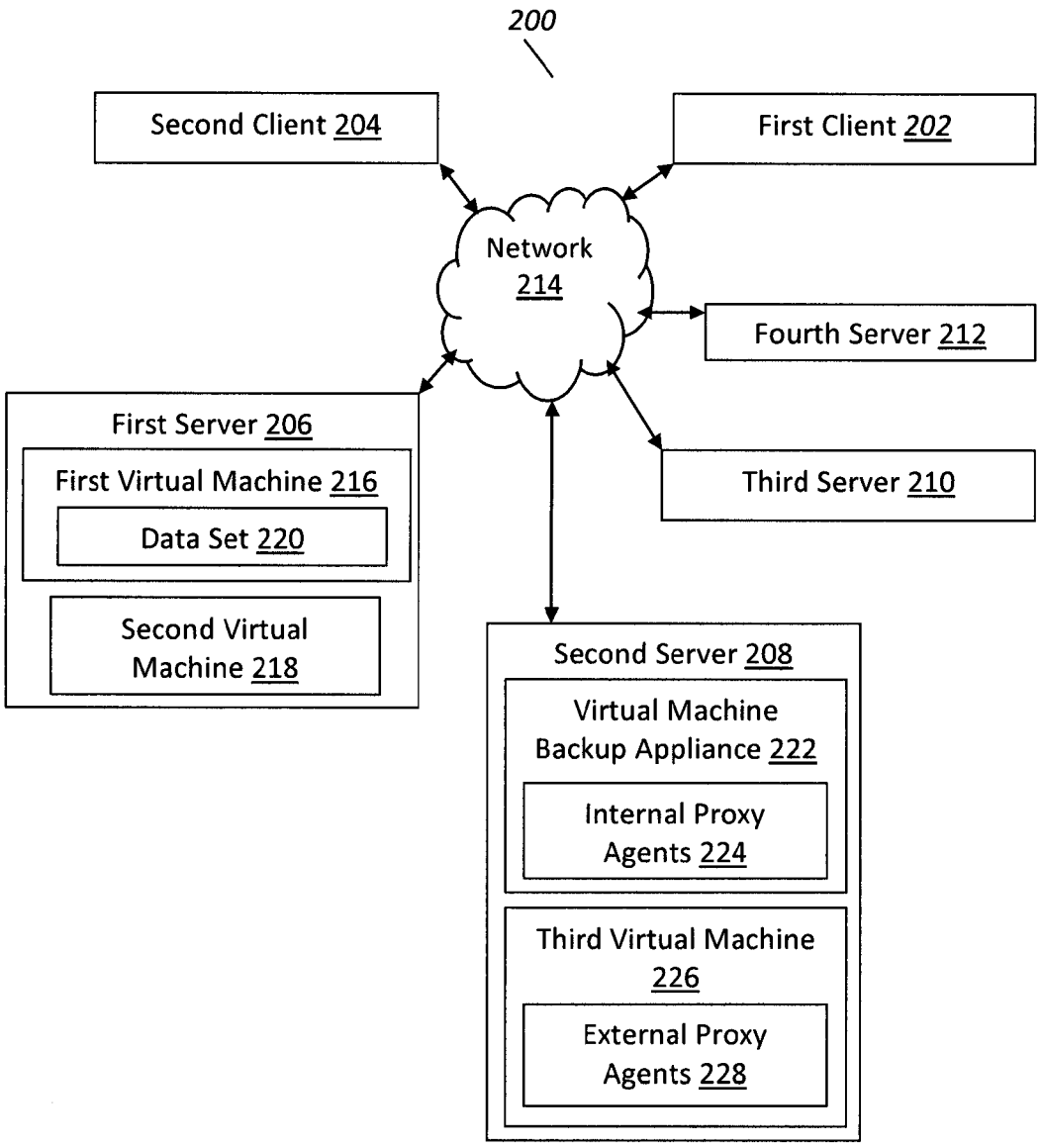

200
Second Client 204
First Client 202
Network 214
Fourth Server 212
First Server 206
First Virtual Machine 216
Data Set 220
Second Virtual Machine 218
Third Server 210
Second Server 208
Virtual Machine Backup Appliance 222
Internal Proxy Agents 224
Third Virtual Machine 226
External Proxy Agents 228

FIG. 2

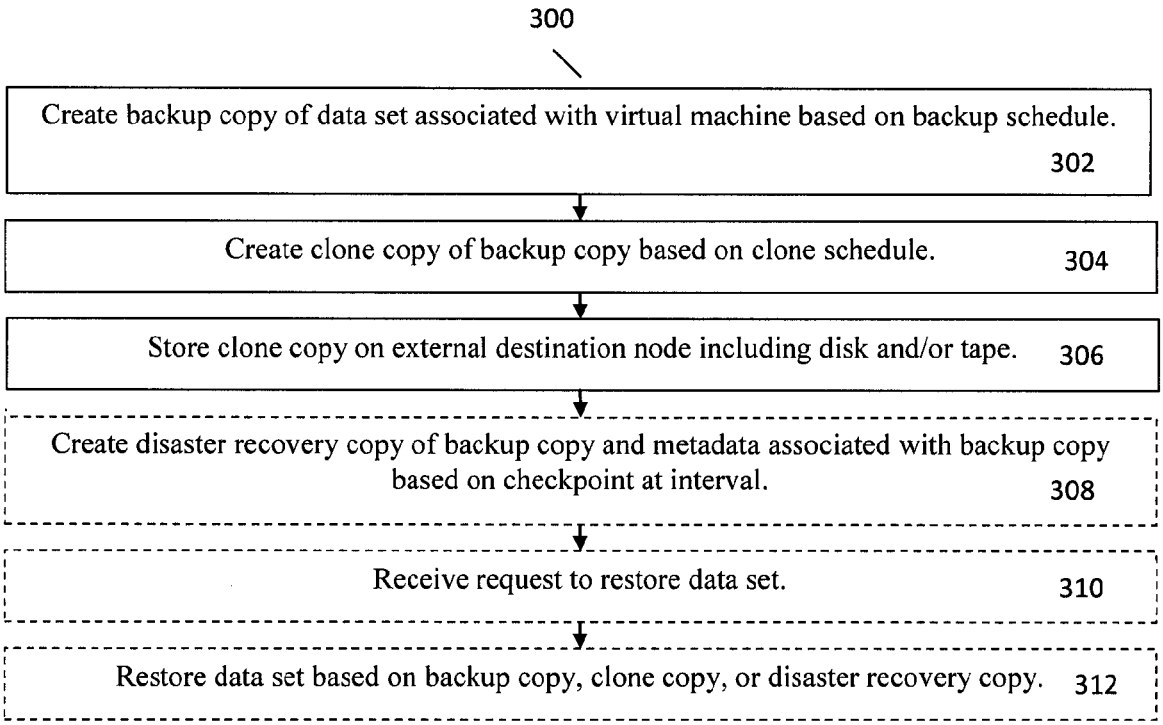

300
Create backup copy of data set associated with virtual machine based on backup schedule.
302
Create clone copy of backup copy based on clone schedule.
304
Store clone copy on external destination node including disk and/or tape.
306
Create disaster recovery copy of backup copy and metadata associated with backup copy based on checkpoint at interval.
308
Receive request to restore data set.
310
Restore data set based on backup copy, clone copy, or disaster recovery copy.
312

FIG. 3

METHOD AND SYSTEM FOR VIRTUAL MACHINE BACKUP

BACKGROUND

If a software error corrupts a database, or if erroneous data updates the database, a database administrator may restore the database to a previous uncorrupted state that does not include the corrupted or erroneous data. A backup application executes a backup operation either occasionally or continuously to enable this restoration, storing a copy of each desired database state (the values of its data and these values' embedding in the database's data structures) within dedicated backup files. When the database administrator decides to return the database to a previous state, the database administrator specifies the desired previous state by identifying a desired point in time when the database was in this state, and instructs the backup application to execute a restore operation to restore a copy of the corresponding backup files for that state to the database. An additional copy that is made of the copy of the backup files and stored separately from the backup files may be referred to as a clone copy of the backup files.

A virtual machine is a software implementation of a computer that executes programs like a physical machine. A system virtual machine provides a complete system platform that supports the execution of a complete operating system, and usually emulates an existing architecture. Multiple instances of virtual machines lead to more efficient use of computing resources, both in terms of energy consumption and cost effectiveness, known as hardware virtualization, the key to a cloud computing environment. Similar to other databases, backup copies are made of virtual machine databases to enable a restoration of the virtual machine database in the event of corruption or an erroneous update to the virtual machine database.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the subject matter claimed will become apparent to those skilled in the art upon reading this description in conjunction with the accompanying drawings, in which like reference numerals have been used to designate like elements, and in which:

FIG. **1** is a block diagram illustrating an example hardware device in which the subject matter may be implemented;

FIG. **2** illustrates a block diagram of an example system for virtual machine backup, under an embodiment; and

FIG. **3** is a flowchart that illustrates a method of virtual machine backup, under an embodiment.

DETAILED DESCRIPTION

In the prior art, a virtual machine backup tool can create a backup copy of a virtual machine database, but the backup copy may be lost if the virtual machine backup tool and/or the backup copy was corrupted. Furthermore, many virtual machine backup tools may be limited to the use of only a small number of internal proxy agents that can execute data protection tasks for virtual machine databases because many virtual machine backup tools have a limited storage capacity.

Embodiments herein provide virtual machine backup. A backup copy is created of a data set associated with a virtual machine based on a backup schedule. For example, a virtual machine backup appliance creates and stores a backup copy of a virtual machine's data set whenever a specified amount of modifications have been made to the data set. A clone copy is created of the backup copy based on a clone schedule. For example, the virtual machine backup appliance periodically creates a clone copy of the backup copy. The clone copy is stored on an external destination node including a disk and/or a tape. For example, the virtual machine backup appliance stores the clone copy on an external disk, thereby protecting a copy of the data set even if the virtual machine backup appliance and/or the backup copy of the data set are corrupted. A disaster recovery copy may be created of the backup copy and metadata associated with the backup copy based on a checkpoint at an interval. For example, a disaster recovery copy is made of the backup copy based on checkpoints at regular intervals. A request to restore the data set may be received. For example, the virtual machine backup appliance receives a request to restore the data set to the virtual machine. The data set may be restored based on the backup copy, the clone copy, or the disaster recovery copy. For example, the virtual machine backup appliance restores the data set to the virtual machine from either the backup copy, the clone copy, or the disaster recovery copy, depending on the availability and creation time of each copy. The virtual machine backup appliance provides full enterprise level protection of data for all of an enterprise's virtual machines.

Prior to describing the subject matter in detail, an exemplary hardware device in which the subject matter may be implemented shall first be described. Those of ordinary skill in the art will appreciate that the elements illustrated in FIG. **1** may vary depending on the system implementation. With reference to FIG. **1**, an exemplary system for implementing the subject matter disclosed herein includes a hardware device **100**, including a processing unit **102**, memory **104**, storage **106**, data entry module **108**, display adapter **110**, communication interface **112**, and a bus **114** that couples elements **104-112** to the processing unit **102**.

The bus **114** may comprise any type of bus architecture. Examples include a memory bus, a peripheral bus, a local bus, etc. The processing unit **102** is an instruction execution machine, apparatus, or device and may comprise a microprocessor, a digital signal processor, a graphics processing unit, an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), etc. The processing unit **102** may be configured to execute program instructions stored in memory **104** and/or storage **106** and/or received via data entry module **108**.

The memory **104** may include read only memory (ROM) **116** and random access memory (RAM) **118**. Memory **104** may be configured to store program instructions and data during operation of device **100**. In various embodiments, memory **104** may include any of a variety of memory technologies such as static random access memory (SRAM) or dynamic RAM (DRAM), including variants such as dual data rate synchronous DRAM (DDR SDRAM), error correcting code synchronous DRAM (ECC SDRAM), or RAMBUS DRAM (RDRAM), for example. Memory **104** may also include nonvolatile memory technologies such as nonvolatile flash RAM (NVRAM) or ROM. In some embodiments, it is contemplated that memory **104** may include a combination of technologies such as the foregoing, as well as other technologies not specifically mentioned. When the subject matter is implemented in a computer system, a basic input/output system (BIOS) **120**, containing the basic routines that help to transfer information between elements within the computer system, such as during start-up, is stored in ROM **116**.

The storage **106** may include a flash memory data storage device for reading from and writing to flash memory, a hard disk drive for reading from and writing to a hard disk, a magnetic disk drive for reading from or writing to a remov-

able magnetic disk, and/or an optical disk drive for reading from or writing to a removable optical disk such as a CD ROM, DVD or other optical media. The drives and their associated computer-readable media provide nonvolatile storage of computer readable instructions, data structures, program modules and other data for the hardware device **100**.

It is noted that the methods described herein can be embodied in executable instructions stored in a computer readable medium for use by or in connection with an instruction execution machine, apparatus, or device, such as a computer-based or processor-containing machine, apparatus, or device. It will be appreciated by those skilled in the art that for some embodiments, other types of computer readable media may be used which can store data that is accessible by a computer, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, RAM, ROM, and the like may also be used in the exemplary operating environment. As used here, a "computer-readable medium" can include one or more of any suitable media for storing the executable instructions of a computer program in one or more of an electronic, magnetic, optical, and electromagnetic format, such that the instruction execution machine, system, apparatus, or device can read (or fetch) the instructions from the computer readable medium and execute the instructions for carrying out the described methods. A non-exhaustive list of conventional exemplary computer readable medium includes: a portable computer diskette; a RAM; a ROM; an erasable programmable read only memory (EPROM or flash memory); optical storage devices, including a portable compact disc (CD), a portable digital video disc (DVD), a high definition DVD (HD-DVD™), a BLU-RAY disc; and the like.

A number of program modules may be stored on the storage **106**, ROM **116** or RAM **118**, including an operating system **122**, one or more applications programs **124**, program data **126**, and other program modules **128**. A user may enter commands and information into the hardware device **100** through data entry module **108**. Data entry module **108** may include mechanisms such as a keyboard, a touch screen, a pointing device, etc. Other external input devices (not shown) are connected to the hardware device **100** via external data entry interface **130**. By way of example and not limitation, external input devices may include a microphone, joystick, game pad, satellite dish, scanner, or the like. In some embodiments, external input devices may include video or audio input devices such as a video camera, a still camera, etc. Data entry module **108** may be configured to receive input from one or more users of device **100** and to deliver such input to processing unit **102** and/or memory **104** via bus **114**.

A display **132** is also connected to the bus **114** via display adapter **110**. Display **132** may be configured to display output of device **100** to one or more users. In some embodiments, a given device such as a touch screen, for example, may function as both data entry module **108** and display **132**. External display devices may also be connected to the bus **114** via external display interface **134**. Other peripheral output devices, not shown, such as speakers and printers, may be connected to the hardware device **100**.

The hardware device **100** may operate in a networked environment using logical connections to one or more remote nodes (not shown) via communication interface **112**. The remote node may be another computer, a server, a router, a peer device or other common network node, and typically includes many or all of the elements described above relative to the hardware device **100**. The communication interface **112** may interface with a wireless network and/or a wired network. Examples of wireless networks include, for example, a BLUETOOTH network, a wireless personal area network, a wireless 802.11 local area network (LAN), and/or wireless telephony network (e.g., a cellular, PCS, or GSM network). Examples of wired networks include, for example, a LAN, a fiber optic network, a wired personal area network, a telephony network, and/or a wide area network (WAN). Such networking environments are commonplace in intranets, the Internet, offices, enterprise-wide computer networks and the like. In some embodiments, communication interface **112** may include logic configured to support direct memory access (DMA) transfers between memory **104** and other devices.

In a networked environment, program modules depicted relative to the hardware device **100**, or portions thereof, may be stored in a remote storage device, such as, for example, on a server. It will be appreciated that other hardware and/or software to establish a communications link between the hardware device **100** and other devices may be used.

It should be understood that the arrangement of hardware device **100** illustrated in FIG. **1** is but one possible implementation and that other arrangements are possible. It should also be understood that the various system components (and means) defined by the claims, described below, and illustrated in the various block diagrams represent logical components that are configured to perform the functionality described herein. For example, one or more of these system components (and means) can be realized, in whole or in part, by at least some of the components illustrated in the arrangement of hardware device **100**. In addition, while at least one of these components are implemented at least partially as an electronic hardware component, and therefore constitutes a machine, the other components may be implemented in software, hardware, or a combination of software and hardware. More particularly, at least one component defined by the claims is implemented at least partially as an electronic hardware component, such as an instruction execution machine (e.g., a processor-based or processor-containing machine) and/or as specialized circuits or circuitry (e.g., discrete logic gates interconnected to perform a specialized function), such as those illustrated in FIG. **1**. Other components may be implemented in software, hardware, or a combination of software and hardware. Moreover, some or all of these other components may be combined, some may be omitted altogether, and additional components can be added while still achieving the functionality described herein. Thus, the subject matter described herein can be embodied in many different variations, and all such variations are contemplated to be within the scope of what is claimed.

In the description that follows, the subject matter will be described with reference to acts and symbolic representations of operations that are performed by one or more devices, unless indicated otherwise. As such, it will be understood that such acts and operations, which are at times referred to as being computer-executed, include the manipulation by the processing unit of data in a structured form. This manipulation transforms the data or maintains it at locations in the memory system of the computer, which reconfigures or otherwise alters the operation of the device in a manner well understood by those skilled in the art. The data structures where data is maintained are physical locations of the memory that have particular properties defined by the format of the data. However, while the subject matter is being described in the foregoing context, it is not meant to be limiting as those of skill in the art will appreciate that various of the acts and operation described hereinafter may also be implemented in hardware.

To facilitate an understanding of the subject matter described below, many aspects are described in terms of

sequences of actions. At least one of these aspects defined by the claims is performed by an electronic hardware component. For example, it will be recognized that the various actions can be performed by specialized circuits or circuitry, by program instructions being executed by one or more processors, or by a combination of both. The description herein of any sequence of actions is not intended to imply that the specific order described for performing that sequence must be followed. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. In an embodiment, the computer system **100** includes one or more methods for a data protection policy generator.

In the prior art, a backup copy of a virtual machine's data set may be lost if the virtual machine backup tool and/or the backup copy was corrupted. Embodiments herein provide virtual machine backup.

FIG. **2** illustrates a block diagram of a system that implements virtual machine backup, under an embodiment. As shown in FIG. **2**, system **200** may illustrate a cloud computing environment in which data, applications, services, and other resources are stored and delivered through shared data-centers and appear as a single point of access for the users. The system **200** may also represent any other type of distributed computer network environment in which servers control the storage and distribution of resources and services for different client users.

In an embodiment, the system **200** represents a cloud computing system that includes a first client **202** and a second client **204**; and a first server **206**, a second server **208**, a third server **210**, and a fourth server **212** that are provided by a hosting company. The clients **202-204** and the servers **206-212** communicate via a network **214**. Although FIG. **2** depicts the system **200** with two clients **202-204**, four servers **206-212**, and one network **214**, the system **200** may include any number of clients **202-204**, servers **206-212**, and networks **214**. The clients **202-204** and the servers **206-212** may each be substantially similar to the system **100** depicted in FIG. **1**.

The first server **206** includes a first virtual machine **216** and a second virtual machine **218**. The first virtual machine includes a data set **220**. The second server **208** includes a virtual machine backup appliance **222**, and may include a third virtual machine **226**. The virtual machine backup appliance **222** may also be a virtual machine. The virtual machine backup appliance **222** includes internal proxy agents **224** and supports external proxy agents **228**, which are internal proxy agents for the third virtual machine **226**. FIG. **2** depicts the system elements **216-220** residing completely on the first server **206** with the system elements **222-228** residing completely on the second server **208**. However, the system elements **216-228** may reside completely on the first server **206**, completely on the second server **208**, or in any combination of partially on the first server **206**, partially on the second server **208**, partially on the third server **210**, and partially on the fourth server **212**.

A data protection administrator uses the first client **202** to instruct the virtual machine backup appliance **222** to protect the data set **220** used by the first virtual machine **216**, which is accessed by a user via the second client **204** and provided by the first server **206**, by storing various copies of the data set **220** on the servers **208-212**.

The virtual machine backup appliance **222** receives a selection from the first client **202** to protect the data set **220** accessed by the second client **204** via the first virtual machine **216** in the first server **206**. For example, the virtual machine backup appliance **222** receives a selection to create a backup copy of the data set **220** in the first server **206**, and store the backup copy via the second server **208**, based on a backup schedule. The first source, such as the first server **206**, may include multiple source nodes. For example, the first virtual machine **216** may store the data set **220** on a disk associated with the first server **206**. A data protection administrator may use the virtual machine backup appliance **222** to specify a query for data sets, and identify the response to the query as the data set to be copied. The first destination, such as the second server **208**, may include multiple destination nodes, and the multiple destination nodes may include a disk destination node, a tape destination node, and/or a destination node that is a combination of disks and tapes. For example, one of the internal proxy agents **224** or one of the external proxy agents **228** may store the backup copy of the data set **220** on a disk, on a tape, or partly on a disk and partly on a tape associated with the second server **208**.

In the prior art, many virtual machine backup tool may be limited to a small number of internal proxy agents due to limitations on the size of the code that provides the virtual machine backup tool, which means that the virtual machine backup tool is limited to executing a small number of concurrent data protection tasks. The virtual machine backup appliance **222** is deployed as a downloadable open virtualization appliance file, a single compressed file that contains an operating system image, packages, boot scripts, etc. While this deployment limitation on code size also limits the virtual machine backup appliance **222** to a small number of the internal proxy agents **224**, the virtual machine backup appliance **222** may also support an unlimited number of the external proxy agents **228**. The external proxy agents **228** are deployed as part of the third virtual machine **226**, which is also a downloadable open virtualization appliance file, which can be deployed and registered with the virtual machine backup appliance **222**, such that the external proxy agents **228** may be added to the available proxy agent pool for the virtual machine backup appliance **222**.

A data protection administrator may use the virtual machine backup appliance **222** to specify a priority for storing copies of data on destination nodes, such as storing only on disks, or storing on disks before storing on a combination of disks and tapes. Additionally, a data protection administrator may use the virtual machine backup appliance **220** to specify the options for data to be encrypted, deduplicated, and/or compressed while being transmitted from a source, and the options for data to be decrypted and/or decompressed when stored on a destination. Data deduplication significantly reduces backup time by only storing unique daily changes, while always maintaining daily full backups for immediate single-step restore. The transmission of deduplicated backup sends only changed blocks, thereby reducing network traffic.

A backup application may receive a selection from the first client **202** to protect the data set **220** accessed by the second client **204** via the first virtual machine **216** in the first server **206**. For example, a NetWorker® backup application receives a selection to create a clone copy of the data set **220** from a second source, the second server **208**, and store the clone copy in the second destination, the third server **210**, based on a clone schedule. The second source may include multiple source nodes, and the multiple source nodes may include a disk source node, a tape source node, and/or a source node that is a combination of disks and tapes. For example, the second server **208** may store the backup copy of the data set **220** on a disk, on a tape, or partly on a disk and partly on a tape. Similarly, the second destination may include multiple destination nodes, and the multiple destination nodes may include a disk destination node, a tape destination node, and/

or a destination node that is a combination of disks and tapes. For example, one of the internal proxy agents **224** or one of the external proxy agents **228** may store the clone copy of the data set **220** on a disk, on a tape, or partly on a disk and partly on a tape associated with the third server **210**.

EMC Corporation's NetWorker® backup application is a suite of enterprise level data protection software that unifies and automates backup to tape, disk-based, and flash-based storage media across physical and virtual environments for granular and disaster recovery. Cross-platform support is provided for many environments, including Microsoft Windows®. A central NetWorker® server manages a data zone that contains backup clients and NetWorker® storage nodes that access the backup media. The NetWorker@ management console software provides a graphic user interface for functions such as client configuration, policy settings, schedules, monitoring, reports, and daily operations for deduplicated and non-deduplicated backups. The core NetWorker® software backs up client file systems and operating system environment. Add-on database and application modules provide backup services for products such as Microsoft® Exchange Server. Client backup data can be sent to a remote NetWorker® storage node or stored on a locally attached device by the use of a dedicated storage node. EMC Corporation's NetWorker® modules for Microsoft® applications supports Microsoft® products such as Microsoft® Exchange, Microsoft® Sharepoint, Microsoft® SQL Server, and Microsoft® Hyper-V servers. The virtual machine backup appliance **222** may be deployed as a module that plugs into the NetWorker® backup application, which a data protection administrator may access to monitor and control any number of virtual machine backup appliances **222**. The capability of monitoring and controlling any number of virtual machine backup appliances **222**, combined with the capability of each virtual machine backup appliance **222** to support multiple external proxy agents **226** provides the NetWorker® backup application with the capacity to offer full enterprise level protection of data for all of an enterprise's virtual machines.

The virtual machine backup appliance **222** may receive an additional selection to protect the data set **220** accessed by the second client **204** via the first virtual machine **216** in the first server **206**. For example, the virtual machine backup appliance **222** receives a selection to create a disaster recovery copy of the data set **220** and the associated metadata from the third source, the third server **210**, and store the disaster recovery copy in the third destination, the fourth server **212**, based on checkpoints at regular intervals. The third source may include multiple source nodes, and the multiple source nodes may include a disk source node, a tape source node, and/or a source node that is a combination of disks and tapes. For example, the third server **210** may store the clone copy of the data set **220** on a disk, on a tape, or partly on a disk and partly on a tape. Similarly, the third destination may include multiple destination nodes, and the multiple destination nodes may include a disk destination node, a tape destination node, and/or a destination node that is a combination of disks and tapes. For example, the Virtual Machine Backup Appliance **222** executing on the second server **208** may store the disaster recovery copy of the data set **220** and the associated metadata on a disk, on a tape, or partly on a disk and partly on a tape associated with the fourth server **212**. The disaster recovery copy of the data set **220** may be based on checkpoints that the Virtual Machine Backup Appliance **222** created at regular intervals. The Virtual Machine Backup Appliance **222** automatically rolls back the data set **220** to a certain checkpoint during a power up if the preceding shutdown of the first virtual machine **216** was abnormal. Furthermore, an administrator may select to execute a manual rollback to a certain checkpoint selected by the administrator.

A virtual machine center application is executed by a server, such as the second server **208**, to provide a centralized and extensible platform for managing virtual infrastructure. This managing of virtual machine environments enables information technology administrators to have simple and automated control over a virtual environment to deliver infrastructure. A virtual machine center server provides centralized management of virtualized hosts and virtual machines from a single console, and gives administrators visibility into the configuration of all the critical components of a virtual infrastructure, all from one place. With a virtual machine center server, virtual environments are easier to manage, as a single administrator can manage hundreds of workloads, more than doubling typical productivity in managing physical infrastructure. The virtual machine backup appliance **222** is deployed as a module that may plug into the virtual machine center application, which enables the virtual machine backup appliance **222** to access each of the virtual machines monitored and controlled by the virtual machine center application. An administrator may use the virtual machine center application to manually initiate a backup copy and/or a clone copy of a data set via the virtual machine backup appliance **222**.

Data protection administrators may use the virtual machine backup appliance **222** to generate a specific policy based on the specific needs of a customer, and reuse that policy for customers with similar needs. For example, a data protection administrator may use the virtual machine backup appliance **222** to generate a "gold" policy, a "platinum" policy, and a "silver" policy for VMware® clients. The gold policy can specify to store **2** backup copies for each VMware® client onto a first disk for 6 months, store a clone of the backup copies on a second disk for 1 year, and store a secondary clone of the backup copies on a tape for 5 years. In this example, the data protection administrator that used the virtual machine backup appliance **222** to generate the gold policy for a specific set of VMware® clients may later apply another instance of the same gold policy to a different set of VMware® clients. Similarly, the data protection administrator may apply another instance of the same platinum policy to a different set of VMware® clients. The virtual machine backup appliance **222** provides full enterprise level protection of data for all of an enterprise's virtual machines

FIG. **3** is a flowchart that illustrates a method of virtual machine backup. Flowchart **300** illustrates method acts illustrated as flowchart blocks for certain steps involved in and/or between the clients **202-204** and/or the servers **206-212** of FIG. **2**.

A backup copy is created of a data set associated with a virtual machine based on a backup schedule, act **302**. For example, the virtual machine backup appliance **222** creates and stores a backup copy of the data set **220** for the first virtual machine **216** whenever the first virtual machine **216** has made modifications to the data set **220**.

A clone copy is created of the backup copy based on a clone schedule, act **304**. For example, the virtual machine backup appliance **222** periodically creates a clone copy of the backup copy.

The clone copy is stored on an external destination node including a disk and/or a tape, act **306**. For example, the virtual machine backup appliance **222** stores the clone copy on an external disk associated with the third server **210**, thereby protecting a copy of the data set **220** even if the virtual machine backup appliance **222** and/or the backup copy of the data set **220** stored on the second server **208** is corrupted.

A disaster recovery copy is optionally created of the backup copy and metadata associated with the backup copy based on a checkpoint at an interval, act **308**. For example, the Virtual Machine Backup Appliance **222** makes a disaster recovery copy of the backup copy stored via the second server **208** and stores the disaster recovery copy via the fourth server **212**, based on checkpoints at regular intervals.

A request to restore the data set is optionally received, act **310**. For example, the virtual machine backup appliance **222** receives a request to restore the data set **220** to the first virtual machine **216**.

The data set is optionally restored based on the backup copy, the clone copy, or the disaster recovery copy, act **312**. For example, the virtual machine backup appliance **222** restores the data set **220** to the first virtual machine **216** from either the backup copy stored via the second server **208**, the clone copy stored via the third server **210**, or the disaster recovery copy stored via the fourth server **212**, depending on the availability and creation time of each copy. For example, the virtual machine backup appliance **222** may typically select to restore the data set **220** to the first virtual machine **216** from the backup copy stored via the second server **208**. However, if the virtual machine backup appliance **222** determines that the backup copy stored via the second server **208** is corrupted, the virtual machine backup appliance **222** may select between the clone copy stored via the third server **210** and the disaster recovery copy stored via the fourth server **212**, depending on the most recent creation time of each corresponding copy. Even if the virtual machine backup appliance **222** selects the clone copy stored via the third server **210** or the disaster recovery copy stored via the fourth server **212**, a user requesting the recovery via the first client **202** participates in a single step recovery process, as the user does not have to request the separate loading of any storage medium used for long-term data retention, such as a tape storage. Furthermore, the virtual machine backup appliance **222** may restore the data set **220** to the first virtual machine **216** based on a file level data set, such as the selective restoration of specific files identified by the user via the first client **202**, without the need to restore all of the other files remaining in the data set **220** to the first virtual machine **216**.

Although FIG. **3** depicts the acts **302-312** occurring in a specific order, the acts **302-312** may occur in another order. Executing the flowchart **300** enables virtual machine backup that provides full enterprise level protection of data for all of an enterprise's virtual machines.

The use of the terms "a" and "an" and "the" and similar referents in the context of describing the subject matter (particularly in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation, as the scope of protection sought is defined by the claims as set forth hereinafter together with any equivalents thereof entitled to. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illustrate the subject matter and does not pose a limitation on the scope of the subject matter unless otherwise claimed. The use of the term "based on" and other like phrases indicating a condition for bringing about a result, both in the claims and in the written description, is not intended to foreclose any other conditions that bring about that result. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention as claimed.

Preferred embodiments are described herein, including the best mode known to the inventor for carrying out the claimed subject matter. Of course, variations of those preferred embodiments will become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventor expects skilled artisans to employ such variations as appropriate, and the inventor intends for the claimed subject matter to be practiced otherwise than as specifically described herein. Accordingly, this claimed subject matter includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. A system for virtual machine backup, the system comprising:
- one or more processors;
- a processor-based application stored on a non-transitory computer readable medium, which when executed on a computer, will cause the one or more processors to:
  - create a backup copy of a data set associated with a virtual machine based on a backup schedule;
  - create a clone copy of the backup copy based on a clone schedule; and
  - store the clone copy on an external destination node comprising at least one of a disk and a tape.

2. The system of claim **1**, wherein the processor-based application will further cause the one or more processors to:
- receive a request to restore the data set; and
- restore the data set based on one of the backup copy and the clone copy.

3. The system of claim **1**, wherein the processor-based application will further cause the one or more processors to:
- create a disaster recovery copy of the backup copy and metadata associated with the backup copy based on a checkpoint at an interval;
- receive a request to restore the data set; and
- restore the data set based on the disaster recovery copy.

4. The system of claim **1**, wherein the backup schedule and the clone schedule comprise a data protection policy.

5. The system of claim **1**, wherein at least one of creating the backup copy of the data set comprises at least one of an internal proxy agent creating the backup copy of the data set and an external proxy agent creating the backup copy of the data set, and wherein creating the clone copy of the backup copy comprises at least one of the internal proxy agent creating the clone copy of the backup copy and the external proxy agent creating the clone copy of the backup copy.

6. The system of claim **1**, wherein at least one of creating the backup copy of the data set comprises creating a deduplicated backup copy of the data set, and wherein creating the clone copy of the backup copy comprises creating a deduplicated clone copy of the backup copy.

7. The system of claim **1**, wherein the data set comprises a file level data set.

8. A computer-implemented method for virtual machine backup, the method comprising:
- creating a backup copy of a data set associated with a virtual machine based on a backup schedule;
- creating a clone copy of the backup copy based on a clone schedule; and

storing the clone copy on an external destination node comprising at least one of a disk and a tape.

9. The method of claim **8**, wherein the method further comprises:

receiving a request to restore the data set; and

restoring the data set based on one of the backup copy and the clone copy.

10. The method of claim **8**, wherein the method further comprises:

creating a disaster recovery copy of the backup copy and metadata associated with the backup copy based on a checkpoint at an interval;

receiving a request to restore the data set; and

restoring the data set based on the disaster recovery copy.

11. The method of claim **8**, wherein the backup schedule and the clone schedule comprise a data protection policy.

12. The method of claim **8**, wherein at least one of creating the backup copy of the data set comprises at least one of an internal proxy agent creating the backup copy of the data set and an external proxy agent creating the backup copy of the data set, and wherein creating the clone copy of the backup copy comprises at least one of the internal proxy agent creating the clone copy of the backup copy and the external proxy agent creating the clone copy of the backup copy.

13. The method of claim **8**, wherein at least one of creating the backup copy of the data set comprises creating a deduplicated backup copy of the data set, and wherein creating the clone copy of the backup copy comprises creating a deduplicated clone copy of the backup copy.

14. The method of claim **8**, wherein the data set comprises a file level data set.

15. A computer program product, comprising a non-transitory computer-readable medium having a computer-readable program code embodied therein, the computer-readable program code adapted to be executed by one or more processors to implement a method for virtual machine backup, the method comprising:

creating a backup copy of a data set associated with a virtual machine based on a backup schedule;

creating a clone copy of the backup copy based on a clone schedule; and

storing the clone copy on an external destination node comprising at least one of a disk and a tape.

16. The computer program product of claim **15**, wherein the method further comprises:

receiving a request to restore the data set; and

restoring the data set based on one of the backup copy and the clone copy.

17. The computer program product of claim **15**, wherein the method further comprises:

creating a disaster recovery copy of the backup copy and metadata associated with the backup copy based on a checkpoint at an interval;

receiving a request to restore the data set; and

restoring the data set based on the disaster recovery copy.

18. The computer program product of claim **15**, wherein the backup schedule and the clone schedule comprise a data protection policy.

19. The computer program product of claim **15**, wherein at least one of creating the backup copy of the data set comprises at least one of an internal proxy agent creating the backup copy of the data set and an external proxy agent creating the backup copy of the data set, and wherein creating the clone copy of the backup copy comprises at least one of the internal proxy agent creating the clone copy of the backup copy and the external proxy agent creating the clone copy of the backup copy.

20. The computer program product of claim **15**, wherein at least one of creating the backup copy of the data set comprises creating a deduplicated backup copy of the data set, and wherein creating the clone copy of the backup copy comprises creating a deduplicated clone copy of the backup copy.

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